Measurement of the Fineness of Agricultural Limestone[1, 2]

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Agricultural limestone is produced in Indiana by crushing limestone rock. The material used for limestone applications to soil is either all of the stone crushed to a small size or else it is the finer material screened from the limestone used in the road building industry. The limestones presently being used in Indiana vary widely in the proportions of fine and coarse particles present.

A study of the effect of the fineness of limestone on crop yields was made in field experiments at two locations conducted by the Agronomy Department between 1921 and 1945 (1) (3). The results of these experiments together with those conducted by neighboring states indicated that fineness was an important characteristic of agricultural ground limestone. From this field study it was possible to determine the effects of fineness of limestone in increasing crop yields. The amounts of limestone of several ranges in fineness required to give equivalent results are shown in table I. The particle size distribution

TABLE I

The Effect of Fineness of Agricultural Limestone on the Amount to Apply for Equivalent Results

Fineness Percent Passing a 60-Mesh Sieve	Equivalent Amounts of Limestone Tons per Acre
41-100	1.0
31- 40	1.25
21- 30	1.50
10- 20	2.00

of limestone was evaluated arbitrarily on the basis of the amount passing a 60-mesh sieve. The objective of the research reported here was to determine if one sieve could be used to characterize limestone fineness and to determine which sieve would give the highest correlation.

Procedure

The limestone samples used were from a group collected monthly by the County A.S.C. Committees from each operating quarry in each county. Ninety-nine samples were selected from this source in the ordere received. The samples were mixed and subdivided with a riffle to obtain the sample to be used for the analysis. They were sieved through

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U. S. standard sieves No. 8, 20, 40, 60, 80, 100 and 200 on a Ro-tap shaking machine with a shaking time of five minutes. The amount passing each sieve was determined as a percentage of the total sample.

Experimental Results

The relative value of the limestone samples was determined according to a method developed by Bear and Allen (2). Using this method, the percentage of each size fraction was multiplied by a factor which is related to the rate at which this size fraction dissolves in the soil. Two limestone values were used; one in which the limestone particles above 60-mesh were evaluated at 1.00 and a second in which the particles smaller than 200-mesh were used as the base. The former measurement would evaluate the limestone 2.3 years after application, the latter 3 months after application to the soil. The figures used to determine these limestone values are shown in table II. The fraction of

TABLE II

The Values Used to Determine the Relative Effectiveness of Limestone Samples Differing in Particle Size Distribution

Particle Size	3 Month Value	2.3 Year Value
4- 8-Mesh	8.1	21.2
8- 20- "	17.8	45.1
20- 40- "	41.0	80.3
40- 60- "	67.0	98.7
60- 80- "	86.5	100
80-100- "	90.5	100
100-200- "	99.0	100
less than 200-Mesh	100.00	100

the limestone in each size range was multiplied by the appropriate factor and the values totaled to give a value for each limestone sample.

The percentage of the limestone passing each of the sieves was correlated with the limestone values for the 99 samples. A multiple regression analysis was determined on several combinations of sieves to determine if the combinations gave a higher correlation than any single measurement. The results of these correlations are given in table III.

The coefficients of determination shown in table III express the percentage of the variation in limestone values that is measured by the sieve or sieves used in the correlation. For the 2.3 year evaluation, the 20-mesh sieve gave the highest value measuring 98.2 per cent of the variation. For the 3 month value, a value which characterizes a wider range of particle sizes, the 40-mesh sieve gave the highest value, measuring 98.9 per cent of the variation. The 60-mesh sieve measuring 96.1 per cent of the variation was not significantly lower statistically. None of the multiple correlations where two or more sieves were used gave a significant improvement in the coefficients. This indicates that, for the samples used, there is no advantage in using more than a 40

TABLE III

Coefficients of Determination for the Correlation of Limestone Value with % Passing One or More Sieves

% Passing Sieve No.	Correlated with 2.3 year value	Correlated with 3 month value
Simple Correlations		
8	0.622	0.474
20	0.982	0.928
40	0.928	0.989
60	0.856	0.961
80	0.823	0.942
100	0.791	0.920
200	0.589	0.730
Multiple Correlations		
8 + 100	0.906	0.947
8 + 60 + 100	0.955	0.979
8 + 200		0.824
20 + 100		0.992

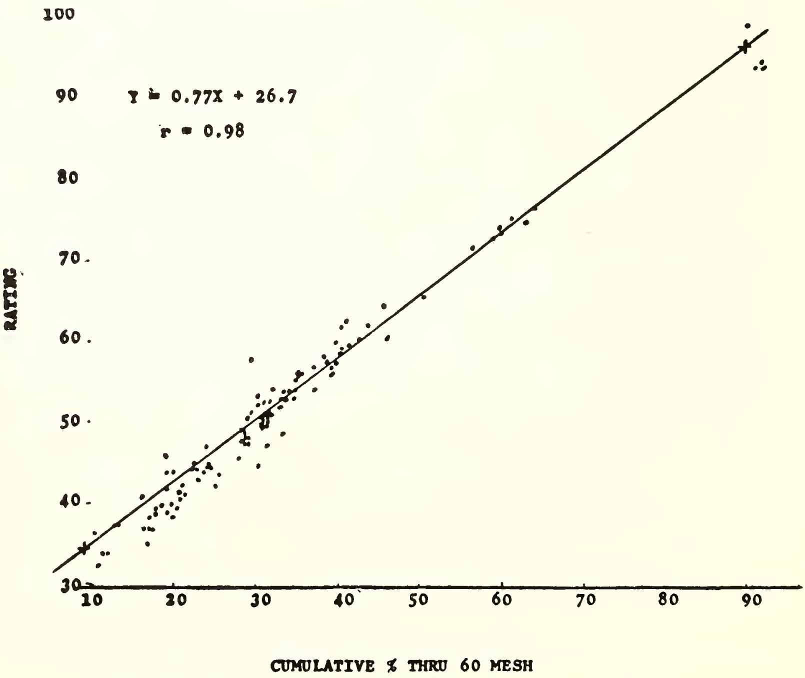

Figure 1. The Relationship between the Value of Limestone and the Percentage which Passes a 60-mesh seive.

or 60-mesh sieve. The relationship between limestone value and the per cent passing a 60-mesh sieve is shown in figure I. The correlation coefficients of all combinations of the sieves is given in table IV. The

TABLE IV

Correlation Coefficients for the Correlation Between Fractions Passing Various Sieves.

Sieve	8	20	40	60	80	100	200
8		.74	.63	.59	.58	.57	.49
20			.95	.90	.88	.86	.74
40				.99	.98	.96	.85
60					.99	.98	.89
80						.99	.91
100							.94

correlation of the amount passing one sieve, for example the 60-mesh sieve, with the amount passing other sieves indicates how well we can predict what will pass other sieves by using this one sieve. The 40, 60 and 80-mesh sieves have higher correlation coefficients in general with the other sieves than do the 8, 20, 100 and 200-mesh sieves. In all of these data, high correlation coefficients are needed since limestone value figure contains a component of any size fraction which is being correlated with it.

The use of a sieve which is in the middle of the particle size range such as the 40 or 60-mesh sieve gives a high correlation with the limestone value and is a good indicator of the particle size distribution of agricultural limestone. The use of more than one sieve did not give a significant increase in the correlation coefficient.

Literature Cited

1. BARBER, S. A. 1955. Liming Indiana Soils, Purdue University, Agricultural Experiment Station Mimeograph AY 124.
2. BEAR, F. E. and L. ALLEN. 1932. Relation between Fineness of Limestone Particles and Their Rates of Solution. Ind. and Eng. Chem. **24**:998-1001.
3. WIANCHO, A. T., G. P. WALKER and S. D. CONNER, 1929. Comparison of Soil Liming Materials, Purdue University, Agriculture Experiment Station Bulletin 329.